

**2005 INTERIM REPORT FOR THE WADESVILLE
MINE POOL WITHDRAWAL AND STREAMFLOW
DEMONSTRATION PROJECT**

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EXECUTIVE SUMMARY

This interim report presents the results for the third year, 2005, of the Wadesville Mine Pool Withdrawal and Streamflow Demonstration Project (Demonstration). During the Demonstration, water pumped from the Wadesville Mine Pool at Pottsville and water released from Still Creek Reservoir at Tamaqua augmented the flow of the Schuylkill River for use as consumptive cooling makeup water by Exelon's Limerick Generating Station (LGS) some 75 miles downriver near Pottstown. Low river flows were experienced during much of the 2005 Demonstration period in sharp contrast to the unusually high flows which prevailed in 2003 and 2004.

This year the Demonstration was governed by Docket Revision 12 which was approved by the Delaware River Basin Commission (DRBC) in October 2004. This Revision allows the Demonstration to extend through 2007, and possibly 2008, in order to monitor for potential environmental impact during more representative low flow conditions and under modified water augmentation conditions.

The main objectives of the Demonstration through 2004 had been to show that water pumped from the Wadesville Mine Pool and released from Still Creek Reservoir (for non-emergency use) can provide a viable supply of water to the Schuylkill River for consumptive use by LGS, allow a corresponding reduction in the amount of water withdrawn from the Delaware River via the Point Pleasant Diversion, and have positive or no substantial effects. In 2005 the Project sought to also demonstrate that withdrawal of limited quantities of unaugmented consumptive cooling makeup water from the Schuylkill by LGS would not have a substantial effect on downstream dissolved oxygen (DO) when ambient river temperatures exceed 59°F and river flows at the Pottstown Gage are above 560 CFS. Additionally, a Restoration and Monitoring Fund was established to implement restoration projects that would improve water quality in the Schuylkill watershed and supplement the benefits of LGS using the new consumptive water withdrawal sources.

The third year of the Demonstration was conducted from May through November following an Operation and Monitoring Plan approved by the DRBC as part of Docket Revision 12. This Plan provides rules for conducting the Demonstration, including operational as well as environmental monitoring responsibilities. The environmental monitoring focused on water quality and aquatic biology.

Several watercourses conveyed water to LGS and were monitored during the Demonstration Project. East Norwegian/Norwegian Creek and the Schuylkill River conveyed Wadesville Mine Pool water. The East Branch Perkiomen Creek and Perkiomen Creek conveyed Delaware River water via the Point Pleasant Diversion Project, but at reduced minimum flow volume during 2005. In addition, water from Still Creek Reservoir, located near Tamaqua, was conveyed to the Schuylkill River by way of Still Creek and the Little Schuylkill River. Monitoring was performed in the Schuylkill River downstream of LGS to determine if the water withdrawals at LGS would cause DO levels to be reduced to below the Pennsylvania Water Quality Standards.

The following is a summary list of the environmental monitoring that was conducted:

- Wadesville Pool water level, discharge rate and quality
- Schuylkill River flow and rainfall
- Lower Schuylkill River DO and other water quality measures
- Pottstown Water Treatment Plant and Pennsylvania American intake water quality

- East Norwegian Creek water quality
- Upper Schuylkill River biology and water quality
- Still Creek Reservoir discharge rate and water quality
- Little Schuylkill River biology, flow, and water quality
- East Branch Perkiomen Creek and Perkiomen Creek water quality

Water was pumped from the Wadesville Mine Pool into East Norwegian/Norwegian Creek on 126 days during the period from May 16 through October 13, 2005 during which time the mine water surface was lowered by a total of about 167 feet. Daily volume of water pumped ranged up to 14 million gallons (MG), with most volumes in the range of 7 to 8 MGD. The total volume discharged for this year's Demonstration was 852.5 MG.

Data was obtained monthly for many water quality parameters, including constituents listed in the Mine's NPDES permit. No measurements, including those for parameters commonly associated with mine water (iron, manganese, and sulfate) were unusually high, based on historical or anticipated levels. Over the three years of the Demonstration, total dissolved solids (TDS) and pH varied within a similar range from year to year and, on average, have been fairly stable. Average values of specific conductance, manganese and sulfate have trended downward over the three years, while average values of iron and alkalinity have increased slightly from year to year.

Water quality sampling results were as expected in East Norwegian Creek and in the Schuylkill River upstream and downstream of the confluence. Generally higher downstream measurements of total dissolved solids, specific conductance, total alkalinity, and pH and generally lower downstream concentrations of total and dissolved iron were observed in 2005, similar to the observations in 2003 and 2004.

Biological resources in the Schuylkill River upstream and downstream of the Norwegian Creek confluence were monitored approximately monthly from May to November. The fish communities at both locations contained a mixture of warmwater species, with blacknose dace, creek chub, white sucker, and green sunfish most abundant. Small numbers of rainbow, brown, or brook trout were collected from both locations; most appeared to be wild fish, while others were apparently stocked. Low numbers of macroinvertebrate taxa were collected at both Schuylkill River locations, and more taxa and more individuals were present downstream than upstream in all collections. The positive results in 2005 were similar to those reported for 2003 and 2004, and support the continued use of the Wadesville Mine Pool.

Dissolved oxygen concentrations were monitored at the LGS Intake, Vincent Pool, Black Rock Dam, and Norristown Pool from April through October. The data indicates that fluctuations in DO were not strongly related to changes in Schuylkill River discharge during periods of low flow. During the months of August and September discharge remained below 800 CFS (mean = 540 CFS) and DO was not strongly correlated to river discharge. For the entire Demonstration, low DO was only a concern at Vincent. However, data quality for this station is questionable. Additionally, DO was not related to consumptive use or changes in water augmentation during the Demonstration. These data support the unaugmented consumptive withdrawal by LGS during the 2006 Demonstration when Schuylkill River discharge exceeds 560 CFS and water temperatures are above 59°F.

Schuylkill River flow was also augmented by discharges from Still Creek Reservoir during the Demonstration. Total volume released was 920 MG from April 14 – November 4 which caused

the Reservoir water surface elevation to decrease by 7.6 feet. The discharges from Still Creek appeared to have a small positive effect on the Little Schuylkill River.

Supplemental Schuylkill River water quality sampling, beyond routine monitoring, was performed on multiple occasions at the Borough of Pottstown's Water Treatment Plant because Schuylkill River flows generally remained low during the Demonstration Project. As predicted, Wadesville Pool water did not impact this or any other public water supply.

The Bradshaw Reservoir pumped releases to the East Branch Perkiomen Creek maintained a minimum stream flow of approximately 10 CFS throughout a major portion of the Demonstration. During two weekend recreational events in May and the period between mid-August and mid-October, the pumping rate was increased to approximately 30 CFS. Monitoring performed in the East Branch and in Perkiomen Creek indicated no adverse impact due to reduced water flow from Bradshaw.

The third year of the Demonstration Project again showed that the Wadesville Mine Pool and Still Creek Reservoir are operationally reliable and environmentally suitable sources of consumptive cooling makeup water for LGS. In addition, the expanded Demonstration showed that withdrawal from the Schuylkill River of a portion of the consumptive water needed by LGS without the restriction related to ambient river temperature did not affect downstream dissolved oxygen compliance with the Water Quality Standards. The results from 2005 support temporary suspension of the temperature restriction during the next Demonstration monitoring period so that LGS can withdraw the full amount of consumptive water with no augmentation until river flows decrease to 560 CFS as provided for in Docket Revision 12.

In 2005, the Demonstration Project resulted in a contribution of about \$158,000 to the Restoration and Monitoring Fund. The Fund will support environmental restoration projects that can improve water quality within the Schuylkill Basin.

1.0 INTRODUCTION

1.1 Overview of the Demonstration Project

In June 2003, Exelon Generation Company LLC (Exelon) received approval from the DRBC via Revision 11 to Docket D-69-210 CP (Final) to conduct a Demonstration Project involving supplementing the flow of the Schuylkill River by pumping water from the Wadesville Mine Pool into the headwaters of the Schuylkill River at Pottsville (Figure 1.1-1). The intent of the project was to augment the flow of the Schuylkill River during the yearly season associated with low river flow and when river temperatures exceed 59°F, and thereby increase the time that LGS would be allowed to withdraw consumptive cooling water from the river. This increase in the use of the Schuylkill River for consumptive cooling use at LGS would allow a corresponding reduction in the amount of water diverted for the same purpose from the Delaware River into the East Branch Perkiomen Creek (EBPC) via the Point Pleasant Pumping Station.

A DRBC-approved Operating and Monitoring Plan was implemented to govern the conduct of the Demonstration and verify that use of the mine water or Still Creek Reservoir water would not cause unacceptable environmental impact. The Delaware River water diversion system was maintained in operation during the pumping Demonstration, in accordance with the requirements of the approved Operating Plan, so that it could be provide the full amount of water required by LGS if necessary. In addition, the Docket revision allowed for releases from Tamaqua's Still Creek Reservoir (subject to its yield curve limitations) at any time rather than only during emergency conditions.

Initially, the Demonstration was scheduled to extend over only one (the 2003) pumping season. However, due primarily to abnormally high ambient streamflow conditions in the watershed which made it difficult, if not impossible, to definitively determine if environmental impacts would develop, the Demonstration was extended to a second (the 2004) pumping season in order to provide additional assurance that the predicted environmental effects will occur from the use of the mine pool source for flow augmentation. Again, abnormally high ambient flow conditions prevailed during the 2004 pumping season.

In mid-2004 Exelon applied to the DRBC for approval to extend and expand the Wadesville and Still Creek Demonstration Project by modifying Schuylkill River withdrawal restrictions related to ambient water temperature, instead relying on a Schuylkill River low flow threshold to trigger flow augmentation from the up-basin sources. In October 2004 the DRBC approved Revision 12 to the Docket which allowed the expanded Demonstration to continue through 2007 with an option to extend through 2008 to demonstrate, under controlled conditions, that withdrawal of Schuylkill River water would not cause adverse impact when ambient water temperatures exceed 59°F, the maximum temperature at which unaugmented withdrawals were permitted under Docket Revision 11. In addition, the project intends to show that no adverse impacts will occur in the East Branch Perkiomen Creek due to replacing the minimum flow requirement of 27 cubic feet per second (CFS) after initiation of pumping at Bradshaw Reservoir with a 10 CFS requirement.

A significant feature of the Demonstration Project which was added in Revision 12 of the Docket is the creation of a Restoration and Monitoring Fund (RMF). Exelon will contribute to the RMF based on the quantities of consumptive cooling water that are not required to be augmented. The

objective is to use the RMF to support restoration projects which can make a significant improvement in water quality within the Schuylkill River Basin.

An interim report for the first Demonstration period, conducted from July through October 2003, was issued in April 2004 and a report for the second Demonstration season, conducted from May through October 2004, was issued in January 2005. The data and analyses for the third Demonstration period, which extended from May to November 2005, are contained in this report.

1.2 Basis for the Project

At full power operation, LGS's per unit consumptive cooling use rates are 17.5 million gallons per day (MGD) average and 21 MGD maximum. These are equivalent to approximately 24,300 gallons per minute (GPM) average and 29,200 GPM maximum for the two units at LGS. The anticipated maximum mine pool yield was approximately 9,000 to 10,000 GPM, which represents approximately 40 percent of the average consumptive cooling makeup requirement for LGS. The balance of the makeup requirement would be provided from Tamaqua's Still Creek Reservoir and the diversion system from the Delaware River. Exelon would operate the mine pool as an underground reservoir with pumping over an approximately 6-month period followed by 6 months of recharge. By using this plan, the pool would be managed as a renewable resource.

The primary drivers for identifying one or more additional sources of consumptive cooling makeup were to expand the source water options available to LGS (thus providing increased reliability and operational flexibility), obtain net environmental benefits to the Delaware River Basin, and reduce Exelon's costs associated with the operation and maintenance of the diversion system.

The project is compatible with Pennsylvania's policy to encourage the use of a mine water source for cooling water purposes in the generation of electricity and, as such, was actively supported by the Pennsylvania Department of Environmental Protection (PADEP). The policy is intended to address the problems associated with the release of acid mine drainage from abandoned, inactive, or underutilized coal mines, which has caused severe adverse effects on the water quality and beneficial uses of Pennsylvania's rivers and streams. This pollution limits the ability of the streams to support abundant aquatic life and recreational activities, and transforms a natural asset into a liability.

The process of searching for a viable water source within the Schuylkill River Basin began in 2002 and led to Wadesville being selected as the leading candidate. The search for alternate water sources found that only mine waters were capable of reliably supplying the sizeable quantities of water required. The Wadesville Mine Pool was the most advantageous source of augmentation water for the Demonstration Project in comparison to other sources considered. Among the reasons that Wadesville was selected were:

- Significant capital improvements were not required to commence pumping in 2003.
- The mine pool water is naturally high in alkalinity, which improves the buffering capacity of the receiving stream.
- The mining company (Reading Anthracite Company or RAC) was willing to commit resources and enter into a binding contract for providing the service of water pumping.

2.0 DESCRIPTION OF THE WADESVILLE MINE SITE

2.1 Project Setting

The productive coal areas in the anthracite region of Pennsylvania are in four distinct fields: Northern, Eastern Middle, Western Middle and Southern. The Southern anthracite field, in which the Wadesville Mine is situated, has an area of about 200 square miles, extending about 70 miles in the east-west direction and 1 to 6 miles wide in Carbon, Schuylkill, Dauphin, and Lebanon Counties from Jim Thorpe and the Lehigh River on the east to the Susquehanna River on the west. The Wadesville mining operation is in the Beechwood-Wadesville-Pine Forest Basin of the Southern Middle Anthracite Field in Schuylkill County (near Pottsville), Pennsylvania, and geologically, in the Llewellyn Formation.

The anthracite region has a long history of extensive deep shaft mining since the early 1800s and surface (strip) mining since the 1940s. These past and ongoing mining operations allow surface water to enter the mine workings and accumulate. The water is impounded in underground pools and in abandoned stripping excavations. Barrier pillars separate the mine pools from each other. The impounded water has to be pumped to the surface or overflows by gravity through drainage tunnels or breaches upon reaching an elevation that varies from pool to pool. There are approximately 31 major underground pools in the Southern field, including Wadesville, plus a larger number of surface pools from stripping operations.

2.2 Wadesville Mine Pool Water Quality

Mining operations allow moisture and air to come into contact with sulfur-bearing minerals (iron sulfides, pyrite, and marcasite) that naturally occur in this region. As a result, chemical reactions take place which lead to the formation of sulfuric acid. Most of the water in the deep mine pools becomes highly acidic and, if allowed to drain into surface waters, the acid mine drainage or AMD becomes an appreciable source of stream pollution. The water in the Wadesville Mine Pool is an exception in that it has a pH in the neutral range (typically 6 to 8) and a moderate level of alkalinity. These characteristics made this source of augmentation water much superior in comparison to several other candidate mine pool sources.

Historically prior to the Demonstration, the acidity levels of the Pool water were negligible [<1 milligram per liter (mg/l)] and the alkalinity levels were on the order of 300-400 mg/l. Specific conductance levels ranged about 1,500-1,800 micromhos per centimeter ($\mu\text{mhos/cm}$), sulfate 500-700 mg/l, and water temperatures 55-60°F.

2.3 Wadesville Mine Works History

The deep mine operation at the Wadesville Colliery was discontinued in 1930, and with the cessation of pumping, the water pool within the mine increased to such a high level that the overflow discharged into Mill Creek at Saint Clair from an abandoned Saint Clair Colliery shaft. In 1949, the now RAC started stripping operations for recovery of coal and installed deep well pump equipment to discharge excess mine water into the Schuylkill River via Norwegian Creek. RAC has continued stripping operations with several interruptions up to the present time period. RAC's future plans to continue mining at Wadesville are not clearly defined. However, without continued pumping, the mine pool elevation would increase until it overflows into Mill Creek.

The potential for this overflow is of concern because of development that has occurred in Saint Clair in the vicinity of the overflow site since the last period of overflow.

2.4 Mine Dewatering Facilities

The existing pump house, which is located at the Wadesville vertical borehole shaft approximately ¼-mile from the open pit, contains pumping equipment used for dewatering of the mine to support present-day surface mining operations. The top of the shaft is at elevation (El) 782 feet above Mean Sea Level (MSL) and the current elevation of the bottom of the pool is at approximately 85 feet MSL. The overflow elevation through an existing pipe at the abandoned Saint Clair shaft is at El 732 feet MSL. A federal government agency estimate of the water volume in the workings in 1953 was 3.4 billion gallons.

Two vertical turbine pumps are installed in the Wadesville mineshaft. Together they have a maximum design discharge rate in the range of 9,000 to 10,000 GPM. Prior to the Demonstration, the pumps operated periodically to maintain the water level at approximately 450 feet (El 332 feet MSL) below the surface to support active strip mining. In the first pumping season the bottoms of the pumps were approximately 500 feet (El 282 feet MSL) below the surface. During 2004 one of the pumps was refurbished and lowered to 600 feet (El 182 feet MSL) below the surface to gain access to additional pool volume. In 2005 both pumps were used as needed until the water level dropped below approximately 500 feet, at which time the pump withdrawing from the 500-foot level shut down. Note that the pump at the 500-foot level developed operating difficulties during the 2005 pumping season and can not be used until it is repaired. The deep pump continued to operate as needed until the conclusion of the pumping season.

The discharge path from the pump house to the Schuylkill River is open-channel flow via a dry swale and then to what is locally known as East Norwegian Creek until it reaches the northern end of Pottsville. At this point, a subsurface conduit channels the flow through Pottsville until it daylights on the southern end and immediately discharges to the Schuylkill River.

3.0 THE DEMONSTRATION PROJECT

3.1 Operation Plan

Part I of the DRBC-approved Demonstration Operation and Monitoring Plan which was included as Attachment 3 to Docket Revision 12, provides rules for continuing the Demonstration of stream flow augmentation by Wadesville Pool and Still Creek Reservoir and for increased withdrawals from the Schuylkill River for some or all of the consumptive cooling makeup at LGS after the 59°F temperature restriction is reached, as long as the Schuylkill River flow at Pottstown is higher than 560 CFS (or 530 CFS if only one LGS unit is operating). It identifies the plan of operation; responsibilities of Exelon, RAC, and DRBC during the Demonstration Project; and specifies the pumping equipment configuration, evaluation criteria, and reporting requirements. In addition, it describes the restoration and monitoring fund that LGS has established to fund projects designed to improve water quality within the Schuylkill River Basin.

3.2 Monitoring Plan

Part II of the Plan specifies the parameters to be monitored, the methodologies, the frequency, and locations to be sampled in order to provide the data necessary to assess the impacts of the mine water and reservoir releases on Norwegian Creek and the Schuylkill River, the increased consumptive withdrawals from the Schuylkill River at LGS, and the decreased diversion flows to East Branch Perkiomen Creek. In short, the monitoring plan was designed to measure water quality and aquatic biological impacts to these waters.

3.3 Affected Surface Waters

Several watercourses conveyed water to LGS during the Demonstration Project. These include East Norwegian/Norwegian Creek, tributary to the Schuylkill River at Pottsville, and the main stem Schuylkill River. Other surface waters were affected by the Demonstration Project as well. Water from Still Creek Reservoir, a public water supply operated by the Tamaqua Water Authority, was discharged via Still Creek to the Little Schuylkill River, which joins the Schuylkill River at Port Clinton some 15 miles downriver of Pottsville. The East Branch Perkiomen Creek and Perkiomen Creek, components of the Point Pleasant Diversion Project, received reduced amounts of water from Bradshaw Reservoir.

Wadesville Mine Pool water was discharged to a swale that ordinarily would be dry, except when it conveys surface runoff in wet periods. The swale connects to East Norwegian Creek, which mostly flows within a constructed channel to the north part of Pottsville where it enters a long underground conduit. Within this conduit, East Norwegian Creek joins with West Norwegian Creek to form Norwegian Creek, which flows through the conduit to the Schuylkill River in Pottsville (Figure 4.5-1). LGS withdraws cooling water from the Schuylkill River approximately 78 miles downriver of Pottsville.

The East Branch Perkiomen Creek receives water from the Point Pleasant Pumping Station on the Delaware River via the intermediate Bradshaw Reservoir. This water is discharged via pipeline to the headwaters of East Branch and then flows to the Perkiomen Creek. From here, the water continues downstream to the Perkiomen Pumping Station for conveyance by pipeline to LGS or, if only the minimum flow of approximately 10 CFS is being released, it is allowed to continue

flowing down the Perkiomen Creek to the Schuylkill River. This system for supply of make-up water to LGS is known as the Point Pleasant Diversion Project.

4.0 MONITORING PROGRAM AND RESULTS

During operation of the Demonstration Project, the following monitoring was conducted in order to assess potential environmental impacts:

- Wadesville Pool water level, discharge rate and quality
- Schuylkill River flow and rainfall
- Lower Schuylkill River dissolved oxygen (DO) and other water quality measures
- Pottstown Water Treatment Plant and Pennsylvania American intake water quality
- East Norwegian Creek water quality
- Upper Schuylkill River biology and water quality
- Still Creek Reservoir discharge rate and water quality
- Little Schuylkill River biology, flow rates, and water quality
- East Branch Perkiomen Creek and Perkiomen Creek water quality

These programs encompassed measurement of a wide range of parameters at differing frequencies. A description of each program element and results obtained during the Demonstration Project follow.

4.1 Wadesville Pool Water Level, Discharge Rate and Quality

Pumping of Wadesville Pool water into East Norwegian Creek for this Demonstration began on May 16 and continued through October 13. The daily total volume of water pumped and the resulting change in mine pool water level were measured. In addition, daily measurements of conductivity were made in the pump discharge flow at the pumphouse. Daily measurements of temperature, pH, and DO were not required or recorded in 2005 since these parameters varied within a narrow range in 2003 and 2004 and were no longer of concern.

The daily total volume of water pumped from the mine pool for LGS use ranged up to 14 MGD and totaled 852.5 MG through the end of the pumping period (Table 4.1-1 and Figure 4.1-1). Most daily volumes pumped were in the range of 7 to 8 MGD. Pumping lowered the mine pool water level approximately 167 feet through the pumping period (Table 4.1-1 and Figure 4.1-1), almost twice the distance in 2004 (84 feet). A detailed analysis of the pumping records and water table variations for 2005 and in comparison to the two prior Demonstration periods is presented in Appendix A of this report.

Specific conductance varied from 1,050 to 1,639 $\mu\text{mhos/cm}$, trending upward for the first few days of the pumping period and then steadily decreasing until pumping was suspended on July 2. Once pumping resumed specific conductance trended downward until mid-September, then trended upward for the remainder of the Demonstration period (Table 4.1-1 and Figure 4.1-2).

Several other water quality parameters were determined monthly and included those required by the mine's NPDES permit plus total organic carbon (TOC), TDS, DO, pH, specific conductance and temperature. Water samples were collected from the pump discharge for analysis.

In general, Wadesville Pool water was neutral in pH with low acidity and relatively high alkalinity (Tables 4.1-2 and 4.1-3). Measurements of the parameters commonly associated with mine water (iron, manganese, and sulfate) were within the expected historical range¹.

Over the three years of the Demonstration, TDS and pH varied within a similar range from year to year and on average have been fairly stable (Tables 4.1-2 and 4.1-3). Average values of specific conductance, manganese and sulfate have trended downward over the three years, while average values of iron and alkalinity have increased slightly from year to year.

4.2 Schuylkill River Discharge and Local Rainfall

Schuylkill River discharge is measured by the U.S. Geological Survey (USGS) at Landingville, Berne, Reading, and Pottstown. These gages are located between the Norwegian Creek confluence and LGS. In addition, rainfall also is measured at Landingville. Data for these locations are presented in Table 4.2-1.

Hydrographs for the Schuylkill River at Landingville (downstream gage located nearest to the Norwegian Creek confluence) and at Pottstown (Figure 4.2-1) show that the 2005 Demonstration was characterized by mostly low river discharge except for two periods of high discharge in early July and October. Monthly mean Schuylkill River flows at these locations in 2005 were much lower than in the preceding years of the Demonstration and were about half the monthly averages for the period of record in May, June, August and September (Table 4.2-2). At Landingville, which is located below the West Branch Schuylkill River but above the Little Schuylkill River confluence, in the two lowest flow months (August and September) the discharge from Wadesville represented about 14% of the average monthly flow. In these same months, the Wadesville discharge represented approximately 2% of the average flow at Pottstown. Rainfall at Landingville during the 2005 Demonstration period was approximately half that recorded in 2004, 21.8 inches compared to 40.3 inches.

4.3 Lower Schuylkill River Water Quality

DO, temperature, pH, and specific conductance were monitored hourly using Hydrolab Minisonde 4A instruments at three locations on the lower Schuylkill River: in front of the LGS cooling water intake, at Black Rock Dam, and in the Norristown Pool (Figure 4.3-1). At the LGS intake, the instrument was suspended just below the water surface from a floating dock located just in front of the intake structure. The monitor in Black Rock Pool was installed within a perforated pipe enclosure affixed to the Dam so that the monitor sampled the water about to flow over the dam. In Norristown Pool, the monitor was installed in a similar enclosure mounted to a support structure on the Norristown (Montgomery County) side of the road bridge leading to Barbados Island. Monitoring began at all three locations on April 15 and continued to late October at LGS and Norristown Pool. The Black Rock Pool recorder was lost during the flooding in early October, thus data for this station is only available until September 30.

¹ Note that when a discharge from an area disturbed by mining activity without chemical or biological treatment has a pH greater than 6.0 and a total iron concentration of less than 10.0 mg/l, as is the case with Wadesville, the PADEP manganese limitations (2.0 mg/l 30-day average and 4.0 mg/l daily maximum) do not apply [ref. 25 PA Code §88.9(c)(2)].

In addition, DO data are available from the USGS for a monitoring station in the pool formed by the partially breached Vincent Dam near Linfield below LGS (Figure 4.3-1). Data from this site are presented for the period from April 15 to October 4, when the USGS suspended the DO monitoring as they usually do until spring. However, there are many data gaps due to equipment problems at this site and the data are sometimes of questionable quality (see below). Exelon is planning to install its own DO monitoring equipment in this section of the Schuylkill River due to the problems with the USGS data.

DO concentrations generally followed the same trend at each of the four stations throughout the Demonstration period (Figures 4.3-2 and 4.3-3) (Table 4.3-1). During the Demonstration period, DO concentrations usually cycled over 24-hour (diel) periods with the highest concentrations found during the late afternoon to early evening hours and lowest concentrations during the early morning hours (Figure 4.3-4). This diel oscillation in DO concentrations is typical of rivers and is primarily due to aquatic vegetation photosynthesis in excess of aquatic organism respiration during daylight and continued respiration with no photosynthesis during the night. Disruptions to the normal diel cycle usually were related to rainfall events and the resulting rise in river flow.

Over the entire monitoring period DO was not correlated with river flow. During specific short periods DO weakly tended to vary with river flow, though higher temperatures may have been more important. The lowest mean daily (5.7 mg/l) and instantaneous (4.3 mg/l) DO concentrations for all four stations were recorded at the Vincent Dam station (Table 4.3-2). The few low instantaneous readings occurred at the bottom of the diel oscillations. The low value was not related to any changes in water supplies or in consumptive water use by LGS. The conditions at the Vincent location are quite different from the other monitoring sites in that the intake for water pumped to the DO monitor is located in a shallow area along the shoreline that is well out of the main river current and relatively stagnant under low flow conditions. The USGS appears to struggle with providing data they consider valid for this station, especially at low river flows.

Two boat surveys were performed to establish DO profiles at several locations in the Black Rock and Norristown pools to ascertain if the Hydrolab monitors were providing representative DO data (Figures 4.3-5 and 4.3-6, respectively). A calibrated YSI Model 57 DO meter was used to measure DO during the surveys which were performed during a period of low, stable river flows. For both pools, multiple transects were surveyed for DO at the water surface, middle of the water column, and bottom of the pool (Tables 4.3-3 and 4.3-4). DO levels measured during the boat surveys and the corresponding percent saturation levels were similar to but slightly lower than the values measured simultaneously with the Hydrolab recorders. The observed differences may be due to the location of the DO monitors at the side of the river and within 3 feet of the river surface at low flow. Based on these limited boat surveys, we judged that the monitors were providing representative data.

To better determine the relationship of DO to flow a more detailed analysis was performed focusing on the August and September period of low river flows when mean daily discharge at Pottstown remained below 800 CFS and lowest DO concentrations and highest river water temperatures were observed. Again, DO concentrations were found to generally vary in a similar pattern at the four stations throughout this period, but the variations appeared to have little relationship to river flow (Figures 4.3-7 and 4.3-8). Scatter plots of mean daily discharge and mean daily DO during August indicated that the DO was not correlated to low flow at LGS, Norristown Pool, and Black Rock Pool and only weakly correlated to flow at Vincent (Figures 4.3-9 and 4.3-10). This analysis indicates that during August, the month with the highest water temperatures, DO concentration was not regulated by river discharge. Thus, at flows between

500 and 800 CFS, consumptive use of up to 10% of river water would have a negligible effect on DO. In effect, the natural variations in river flow mimicked the tests LGS may have done to study the effects of withdrawing the full complement of consumptive cooling water (42 MGD, 65 CFS). In contrast, scatter plots of mean daily discharge and mean daily DO during September indicated that DO was weakly positively correlated to low flow at Norristown Pool, Vincent Dam, and Black Rock Pool and not correlated to flow at Limerick (Figure 4.3-10). However, DO concentrations were higher in September and were well above the minimum Water Quality Standards. The differences between August and September may indicate that during low flow water temperature may be more important in determining dissolved oxygen concentrations than river discharge. For both months, river flows were similar but water temperatures were lower and DO concentrations were higher in September (Figures 4.3-11 and 4.3-12). However, cooler water temperatures in September are coincident with other confounding factors (e.g., shorter day length and changes in aquatic vegetation biomass).

In general, mean pH over the sample period was similar for all three stations with lowest mean (7.88), minimum (6.22), and maximum (9.78) values found at the Norristown Pool station (Table 4.3-5). Diel variation in pH was observed, as expected, coincident with the cycling of DO. Photosynthesis by aquatic plants removes carbon dioxide from water during daylight, thus causing a rise in pH.

4.4 Lower Schuylkill River Water Treatment Facilities

Pottstown Water Treatment Plant

The Borough of Pottstown's Water Treatment Plant is the first drinking water intake on the Schuylkill downstream of Pottsville and, therefore, the first intake potentially affected by water pumped from the Wadesville Mine Pool. Pottstown routinely measures the pH and specific conductance of the raw water withdrawn from the Schuylkill River. We utilized their data to supplement our own data collection efforts. The pH of the intake water is recorded at 2-hour intervals each day. The observed daily ranges are shown in Table 4.4-1. During the Demonstration, intake water pH ranged from 6.5 to 8.3 standard units. Although the daily range on most dates was 0.2 standard units or less, the greatest range observed was 1.3 standard units on May 12, prior to initiation of Wadesville Mine Pool pumping. This occurred during a period of low, stable, river flows which appeared to coincide with the onset of intense photosynthesis with its wide swings in DO and pH as shown by the data obtained simultaneously at the LGS intake.

The daily measurements of specific conductance ranged from 370 to 570 $\mu\text{mhos/cm}$, with most readings in the 400s. This parameter was strongly negatively correlated with river discharge (Figure 4.4-1). Conductivity and pH values ranged higher in 2005 than in the 2004 Demonstration period, coincident with the lower flow regime observed in 2005.

Sampling of additional parameters, i.e., TDS, iron, manganese, total organic carbon (TOC), and sulfides was scheduled to take place at the Pottstown water intake when river flows at the USGS Pottstown gage decreased below 840 CFS. The purpose of this sampling was to assure that Borough personnel were informed about water quality trends that could result in increased treatment costs or potentially cause a violation of the drinking water quality limits applicable to the finished water. Daily average Schuylkill River flows fell below the trigger level and increased monitoring was performed on 17 days from June 17 to October 6 (Table 4.4-2). Maximum concentrations found during the 17 sampling events were: iron, 0.44 mg/l; manganese, 0.205 mg/l; sulfide, <2.0; copper, <0.01 mg/l; TOC, 2.8 mg/l; and TDS, 350 mg/l (Table 4.4-2). Pottstown was not required to make any changes to public water supply treatment as a result of

the implementation of the Demonstration Project in 2005. As noted previously in Section 4.2, the pumped flow from Wadesville represents only about 2% of the river flow at Pottstown under low flow conditions, i.e. with 10 CFS pumped and 500 CFS river flow at Pottstown.

Pennsylvania American Water Company

The Pennsylvania American water intake on the Schuylkill River near Linfield (below LGS but upstream of the Vincent Pool USGS monitoring site) was sampled for TDS on 12 occasions from April 18 to October 3. Sampling occurred monthly, then weekly when river flow at the Pottstown gage fell below 560 CFS. TDS ranged from 173 to 460 mg/l with all values being below the threshold limit for finished drinking water. TDS was strongly negatively correlated with river discharge (Figure 4.4-2). DO, specific conductance, pH, and temperature were also determined (Table 4.4-3).

4.5 East Norwegian Creek and Upper Schuylkill River Water Quality

Water quality sampling was conducted at single locations in East Norwegian Creek and in the Schuylkill River upstream and downstream of the confluence, coincident with Schuylkill River biological monitoring (Figure 4.5-1). The East Norwegian Creek station is located near Coal Street in Pottsville, immediately upstream of the long culvert which conveys the stream underground through Pottsville. Schuylkill River Station 106 is located approximately 0.5 mile upstream of the mouth of Norwegian Creek, while Station 109 is located approximately 3 miles downstream of the confluence.

Based on our data, mixing Norwegian Creek water with the Schuylkill River seemed to have a small positive effect downstream of the confluence (Table 4.5-1). Total dissolved solids, specific conductance, total alkalinity, and pH were generally higher downstream. Total and dissolved iron values were generally lower downstream. These same relationships were observed in 2003 and 2004.

Daily water temperature measurements were recorded using Onset StowAway temperature loggers in East Norwegian Creek and at Schuylkill River Station 109 where biological and water quality sampling was conducted. The temperature logger upstream of the Norwegian Creek confluence was positioned at Station 107 which is located between the confluence and Schuylkill River biological monitoring Station 106. This is the same location that was monitored for ambient river temperature in prior years of the Demonstration.

As expected, the East Norwegian Creek discharge had a slight cooling effect on the Schuylkill River, but this effect did not persist very far downstream. Mean daily temperatures in the Creek were regularly lower than the Schuylkill River at Stations 107 and 109 (Figure 4.5-2). However, the water temperature at Station 109, approximately 3 miles downstream of the Norwegian Creek confluence, was generally the warmest.

4.6 Upper Schuylkill River Biological Monitoring

Schuylkill River biological monitoring began on May 19, three days after Wadesville Pool pumping was initiated, and was repeated three more times (June 24, August 10, and September 16) during the operational period and once shortly afterward (November 3). The biological monitoring consisted of sampling fish and benthic macroinvertebrates (aquatic insects and other organisms that live on or in the river bottom) present at indicator stations in the Schuylkill River

upstream (Station 106) and downstream (Station 109) of the Norwegian Creek confluence (Figure 4.5-1). Stations 106 and 109 are part of the array of Schuylkill River locations previously sampled by the Pennsylvania Fish and Boat Commission.

Consistent methods were used in the biological monitoring in order to aid in evaluation of the data. Fish were captured by electrofishing in approximately equal lengths of river at both stations. Captured fish were identified, counted, measured for total length, and released live to the river. Benthic macroinvertebrates were collected during single 15-second kick samples in two fast water velocity riffles and two slower water velocity riffle/runs using a D-frame kicknet. The kick samples for each station were combined and were preserved with isopropanol for transport to the laboratory where all macroinvertebrates were sorted from sample residue, identified, and counted. Both the fish and benthic macroinvertebrate sampling methods are standard procedures in aquatic biological investigations and were used in the previous Demonstration periods.

The results of fish sampling are shown in Tables 4.6-1 and selected data are graphically presented in Figure 4.6-1. Similar fish species composition was present at both stations. A total of 9 species were collected at Station 106 while 13 species were collected at Station 109. Excluding hatchery-reared trout, the most common species were blacknose dace, creek chub, white sucker, and green sunfish. Greater numbers of individuals were also captured downstream.

Rainbow, brown, or brook trout were captured at both stations on each sampling date, but salmonids were only a small proportion of the total fish collected. Greater numbers of salmonids were found at Station 109 than Station 106. Most of the salmonids were wild brook or brown trout, similar to the data collected in 2004.

These results are similar to what was observed in 2003 and 2004 and indicate little effect of the Norwegian Creek discharge even during a period of low Schuylkill River flow. There was little difference in species composition and in which were most abundant between the stations on any sample date. Furthermore, relatively similar total numbers of fish, including trout, were captured at both stations on all sample dates. The variation in numbers between the stations and from sample date to sample date was not unexpected for the species that were present and the habitat conditions observed.

The results of the benthic macroinvertebrate sampling are shown in Table 4.6-2 and selected data are graphically presented in Figure 4.6-2. More macroinvertebrates and more taxa consistently were collected downstream than upstream of the Norwegian Creek confluence. This differential was most pronounced in the numbers of individuals collected. Macroinvertebrate relationships observed in 2005 were similar to those observed in 2003 and 2004.

Taxonomic composition was limited at both stations. A total of 23 distinct macroinvertebrate taxa were collected upstream at Station 106 and a total of 25 taxa were collected downstream at Station 109. Of the insect taxa considered intolerant of environmental disturbance, few mayflies (Ephemeroptera) and stoneflies (Plecoptera) were collected at either station. However, of the mayflies collected, three mayfly genera were collected downstream and no mayfly genera were collected upstream of the East Norwegian Creek confluence. Four caddisfly (Trichoptera) taxa, also considered disturbance-intolerant, were collected at the two stations, with greater numbers of individuals collected downstream of the Norwegian Creek confluence.

Other macroinvertebrate taxa present at one or both stations included such crustaceans as crayfish (Decapoda), scuds (Amphipoda), sowbugs (Isopoda), and worms (Oligochaeta), in addition to several more insect groups. Most noteworthy among the insects, other than the intolerant groups

discussed above, were the midges (Chironomidae). Midges were the dominant taxon among all sample dates for both stations. The midges are composed of many species, are widespread in distribution, and their presence in relatively large numbers is not unusual.

Mine water pumping may have benefited the macroinvertebrate community, noting that more macroinvertebrate taxa and individuals were collected downstream than upstream. This enhanced macroinvertebrate community translates to a more abundant food resource for fish.

4.7 Still Creek Reservoir Discharge Rate and Water Quality

Discharges from Still Creek Reservoir were used to augment Schuylkill River water volume, not for water quality enhancement or TDS management. During the Demonstration, daily discharge reached a maximum of approximately 27 MGD but was less than 11 MGD for most days and totaled 920.6 MG for the 2005 Demonstration period (Table 4.7-1).

Through the entire Demonstration period, water surface elevation decreased by 7.6 feet. This decrease is much greater than in previous years due to the below average rainfall in the area during 2005. However, significant rainfall in October raised the reservoir 2 feet from the lowest elevation which was recorded in late September. By the beginning of December the reservoir level had recovered another 3.6 feet and was about 2 feet below the spillway level. These fluctuations are normal and expected for a well-run water supply reservoir. Additionally, the Still Creek Reservoir was operated within the minimum storage limits established in the Operating Rule Curve for the reservoir.

Weekly measurements of DO in Still Creek below the reservoir varied within a very satisfactory range from 6.4 to 10.8 mg/l. The range of DO concentrations was similar to the 2003 and 2004 Demonstration periods.

4.8 Little Schuylkill River Water Quality and Discharge

Water quality sampling was conducted at three locations within the upper Little Schuylkill River watershed, upstream of Tamaqua, on a monthly basis when releases were being made from Still Creek Reservoir. The sampling stations were located in the Little Schuylkill River upstream of Still Creek below the SR 1020 bridge, in Still Creek near the PA Route 309 bridge (about 0.4 mile below Still Creek Reservoir), and in the Little Schuylkill River near the PA Route 54 bridge downstream of Still Creek and just above the confluence with Pine Creek (Figure 4.8-1). These locations were selected to determine the influence of Still Creek Reservoir releases on the Little Schuylkill River which has very poor water quality due to acid mine drainage above the Still Creek confluence. Water samples were collected for lab analysis of TDS and total alkalinity; field determinations of DO, specific conductance, temperature, and pH were performed at the time of sampling.

Onset temperature loggers were installed at the same locations where water quality sampling was conducted and an additional logger was placed at a downstream location in the Little Schuylkill River about 1.3 miles north of Tamaqua. Field determinations of DO, specific conductance, temperature, and pH were performed and aquatic habitat observations were recorded at each of the four stations when the temperature recorders were downloaded monthly.

For all sampling dates the TDS, pH, and total alkalinity in the Little Schuylkill River were higher downstream of the Still Creek confluence than above. DO and specific conductance were lower for all sampling dates downstream of Still Creek.

Water temperatures at the two Little Schuylkill River stations downstream of Still Creek and in Still Creek were warmer than in the Little Schuylkill River upstream of Still Creek (Figure 4.8-2). The upper Little Schuylkill River station was on average 5°F cooler than the other three stations and had the smallest variation in temperature throughout the study period. Flow at this location appeared to be dominated by mine drainage. The higher temperatures and wider range of temperatures at the lower sites appears to reflect natural warming that takes place as rivers flow downstream. An added influence was the warmer water released from Still Creek Reservoir after July.

Water quality measurements taken during temperature logger downloads followed the same trends as described previously (Table 4.8-1). Aquatic habitat observations indicated limited changes among the four stations during the Demonstration period except for slight increase in algal growth at the two lower Little Schuylkill River stations (Table 4.8-2).

Little Schuylkill River and Still Creek discharge rates were recorded from April to November 2005. Little Schuylkill River discharge was determined both upstream (75 ft) and downstream (200 ft) of Still Creek and Still Creek discharge was determined just upstream (150 ft) of the confluence with the Little Schuylkill River (Figure 4.8-3). An In-Situ MinTroll pressure recorder was used to measure pressure hourly at each location. Pressure was then converted to water depth (feet) above the pressure recorder. Pressure measurements were recorded throughout the data collection period and manual stream discharge estimates were determined on six separate days for a range of flows in order to generate a rating curve to convert pressure readings to stream flow. A simple regression model was used to develop a straight line equation that was then used to estimate stream discharge at a given pressure.

Mean daily estimates of discharge were calculated for each station. Water depth values outside the range of values used to develop the regression equation (e.g. during high flow events associated with storms) were not used to determine discharge, thus discharge was not calculated for all days during the Demonstration. When releasing, Still Creek Reservoir discharge contributed a large portion of the total flow of the Little Schuylkill River (estimated mean discharge = 10.2 cfs). During the entire monitoring period, mean estimated discharge was 7.1 cfs for Still Creek, 6.8 cfs for Little Schuylkill River upstream of Still Creek, and 13.1 cfs for Little Schuylkill River downstream of Still Creek. Estimated discharge of all three stations followed a similar trend throughout the Demonstration period (Figure 4.8-4).

4.9 Little Schuylkill River Biological Monitoring

Fish communities were surveyed at five different locations upstream and downstream of the Still Creek confluence with the Little Schuylkill River in May, July, and November. Two sites were sampled upstream of the discharge from Still Creek Reservoir and three sites were sampled downstream (Figure 4.9-1). A combination of electrofishing and angling techniques were used to complete the fish surveys. Captured fish were identified, measured for length, enumerated and released. In addition, water temperature, DO, pH, and specific conductance were recorded during sampling (Table 4.9-1).

No fish were found in the Little Schuylkill River upstream of the Still Creek confluence. However, a wild population of brook trout was observed upstream of the confluence in an unnamed tributary to the Little Schuylkill River. In the stream section extending downstream from Still Creek to the dry dam flood control structure, one tessellated darter and a few brook trout were collected. It appears that the Still Creek discharge may increase the pH of the Little Schuylkill enough (from about 5.2 to 5.6) to allow some fishes to inhabit this section of the river. However, fish are prevented or hindered from moving upstream into this section by the box culvert into which the Little Schuylkill River flows on its way past the dry dam. From the dry dam downstream to Route 54 (just upstream of the Pine Creek confluence), brook trout, chain pickerel, creek chub, and white suckers were present. Downstream of Pine Creek the fish diversity increased and a total of nine species were collected. The Pine Creek tributary further improves the water quality (e.g., increases the pH) of the Little Schuylkill River so that it is habitable for some additional species.

4.10 East Branch Perkiomen Creek and Perkiomen Creek Water Quality

Measurements of selected water quality parameters were made in the outfall from Bradshaw Reservoir as well as at three locations in East Branch Perkiomen Creek five times per month during the Demonstration period (Figure 4.10-1). Both *E. coli* and fecal coliforms numbers were much higher in the East Branch upstream of the Bradshaw Reservoir outfall, compared to downstream on most sample dates (Table 4.10-1), the same as in 2003 and 2004. Mean monthly *E. coli* and fecal coliform counts were also higher upstream. DO levels generally were similar upstream and downstream of the Bradshaw Reservoir outfall in 2005 and were comparable to years 2003 and 2004. These results suggest that the reduced minimum flows in the East Branch Perkiomen Creek are not having an effect on bacteria levels.

Monthly water quality measurements made in Perkiomen Creek upstream and downstream of the East Branch Perkiomen Creek confluence generally indicated small differences in the measured parameters between these locations (Figure 4.10-1), as were observed in 2003 and 2004. The relatively high measurements of *E. coli* and fecal coliforms during July at the downstream Perkiomen Creek location appear to be related to something occurring in the Perkiomen upstream of the East Branch confluence (Table 4.10-2). The East Branch results were much lower.

Flows from Bradshaw Reservoir were reduced to approximately 10 CFS for most of the Demonstration period (Figure 4.10-2). The flows in the upper East Branch Perkiomen Creek as monitored by the USGS Dublin gage closely reflect the discharge rate from Bradshaw Reservoir except during precipitation events. We did not observe any effects due to flow reduction, and we received no comments of concern from the public or stakeholders.

Sampling for fish and benthic macroinvertebrates was performed at four locations distributed throughout the East Branch in 2005. This work is a continuation of a sampling program that has been in place for many years to monitor the aquatic community subsequent to water releases from Bradshaw Reservoir. The results of this monitoring effort will be reported separately at a later date since the sampling results are not available for inclusion in this report.

5.0 CONCLUSIONS

This year's Demonstration allowed for data collection during a year with below average precipitation and much lower river flows than in the previous Demonstration periods. The Demonstration again showed that the Wadesville Mine Pool is a viable and environmentally suitable source of a significant quantity of consumptive cooling water for LGS even during a year of below-average precipitation.

Releasing the mine pool water to the Schuylkill River and expanded releases from Still Creek Reservoir had positive effects on flow and water quality. During low flow periods the mine water and Reservoir releases substantially augmented the flow in the upper reaches of the Schuylkill River Basin.

Partial suspension of the temperature restriction on withdrawal of a portion of the consumptive water required by LGS did not affect DO levels in the lower Schuylkill River. DO levels were not correlated to flow reductions related to water withdrawal by LGS and DO levels met the Water Quality Criteria.

The minimum flow releases to East Branch Perkiomen Creek maintained stream flow in the East Branch during a period of near-drought conditions and enhanced the flow in the Perkiomen Creek downstream of LGS's Graterford intake. No stakeholder concerns were received regarding lower flow in the East Branch.

The results from 2005 support further relaxation of the temperature restriction during the next Demonstration monitoring period so that LGS can withdraw the full amount of consumptive water with no augmentation until river flows decrease to 560 CFS. Based on the monitoring results obtained to date, particularly during the low flow period of 2005, a reduction in the frequency of biological and water quality monitoring is scientifically justified in Norwegian Creek and the upper Schuylkill River. Likewise, continued monitoring is not justified at the Pottstown water intake.